GEOGRAPHICAL STUDY OF WETLANDS IN VAISHALI DISTRICT WITH SPECIAL REFERENCE TO LAKE BARAILA

RESEARCH SYNOPSIS
SUBMITTED IN PARTIAL FULFILMENT REQUIRED FOR THE DEGREE OF PHILOSOPHY IN GEOGRAPHY

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INTRODUCTION

A wetland is a place where the land is covered by water. Marshes, ponds, the edge of a lake/ocean, the delta at the mouth of a river, low-lying areas that frequently flood — all of these are wetlands (National Geographic). It is also considered the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life. (National Geographic)

Wetlands are areas where water is the primary factor controlling the environment of different species that are present there (Aslam A. et.al 2022). They occur where the water table is at or near the land's surface, or where the land is covered by water. Wetlands are transition zones **(**ecotone**)** between terrestrial and aquatic ecosystems. E.g. Mangroves, lake littorals (marginal areas between the highest and lowest water level of the lakes), floodplains (areas lying adjacent to the river channels beyond the natural levees and periodically flooded during high discharge in the river), and other marshy or swampy areas (CNHBSI 2018). These habitats experience periodic flooding from adjacent deepwater habitats and therefore support plants and animals specifically adapted to such shallow flooding or waterlogging. Waterlogged soil-adapted plant life (hydrophytes), and hydric soils (not enough O_2) are the chief characteristics of wetlands (DEPSFG 2011). Natural wetlands in India range from high altitude wetlands in the Himalayas; flood plains of the major river systems; saline and temporary wetlands of the arid and semi-arid regions; coastal wetlands such as lagoons, backwaters, estuaries, mangroves, swamps and coral reefs, and so on (US EPA). According to the National Wetland Conservation Programme (NWCP), the Government of India operationalized the National Wetland Conservation Programme (NWCP) in close collaboration with the concerned State Government during the year 1985 and 1986. Under the program, 115 wetlands have been identified till now by the Ministry which requires urgent conservation and management initiatives. The main wetland types are swamp, marsh, bog, and fen. Subtypes include mangrove forests, carr, floodplains, sink, and many others (Mitsch W J and Gosselink J G, 2015). As India continues to address the challenges and opportunities associated with wetland conservation, it underscores the significance of safeguarding these invaluable ecosystems. The NWCP and Ramsar Sites represent vital steps toward achieving these goals and ensuring a sustainable and harmonious coexistence between people and wetlands in India (Prasad S N et al., 2002). The Ramsar

Convention on Wetlands of International Importance is an international treaty for the conservation and sustainable use of wetlands. It is named after the city of Ramsar in Iran, where the Convention was signed in 1971(Ramsar org.). Every three years, representatives of the Contracting Parties meet at the Conference of the Contracting Parties (COP). On the 2nd of February each year World Wetlands Day is celebrated to aware people of its conservation (Ramsar org.). A wetland can be considered to be internationally important if any of the following criteria apply -"it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region"(DCCEEW). Wetlands act as natural barriers that hold and release floodwaters, precipitation, snowmelt, groundwater, and surface water which slows the speed of flood water and prevents soil erosion (Ghose D S, 2006). Wetlands offer important benefits to industry as well. For example, they are essential to the recreational as well as commercial fishing sectors and provide nurseries for fish and other freshwater and marine organisms (Prasad S N et al., 2002). Wetlands are essential for life on the Earth. They support a great diversity of life, including plants and creatures that cannot be found anywhere else, and they serve as a habitat for both animals and plants (Prasad S N et al., 2002). Many threats also faced by wetlands are urbanization, agricultural activities, climate change, pollution, dredging, draining, introduced species, and salinization (Ghose D S, 2006). Important wetlands of the world, Western Siberian Lowland is considered the world's largest wetland in the region of central Russia. Some of the other major world wetlands are the Amazon River Basin in South America, the Hudson Bay Lowland in North America, the Congo River Basin in Africa, and the Mackenzie River Basin in North America. According to the Wetlands of India portal, the present status of wetlands is as follows: the total number of wetlands is 1277, Ramsar wetlands are 80, significant wetlands are 114 and other wetlands are 1083. Bihar's estimated total wetland area is 403209 hectares or 4.4% of the country's total land area. The most common types of wetlands are rivers and streams, which make up over 74% of all wetlands (298408 ha), naturally waterlogged areas (34878 ha), lakes and ponds (20281 ha), and ox-bow lakes and cut-off meanders (16172 ha). In Bihar, inland natural wetlands are around 92% of the total wetland area, while the remaining 3.5% of wetlands are man-made. (NWIA 2011). Some important wetlands of Bihar are Kusheshwar Asthan in Darbhanga, Kabar Taal in Begusari, Baraila Jheel in Vaishali, Kothiya Maun in southeast of Motihari, Nakti Dam Bird Sanctuary in Katihar, Chaurs of North Bihar in Patna, Diyara Flood Plain in Pashchim Champaran, Gogabil Pakshi Vihar Baghar Beel and Baldia Chaur in Patna, and Kursela River Course in Purba Champaran, (National Wetland Atlas 2011).

BARAILA WETLAND OF VAISHALI DISTRICT

Baraila Wetland is one of the floodplains, which is located in Hazrat Jandaha Tehsil of Vaishali district of Northern Bihar, India (Kumari P. et. al 2023). The wetland expands to 12.5 km long (east to west) and 8 km wide (north to south) (CNHBSI 2018). The area of the wetland is nearly 12.7 km sq. and it is about 56 km from Patna while from Hajipur it is 40.7 km (Ashraf M. and Nawaz R. 2015). This wetland is part of a single large eutrophic seasonally flooded marsh (Chaurs). In 1997 the Bihar government declared it a century for the conservation of migratory water birds of the lower Gangetic plains (Kumari P. et. Al 2023). This wetland is surrounded by four rivers e.g. Gandak, Nuna, Burhi Gandak, and Ganga. Baraila wetland used to be the budding ground for the host of floral and faunal species which form important trophic components of the ecological pyramid. (CNHBSI 2018) The wetland is surrounded by eight villages along its boundary: Kawai Baraila in the north; Loma, Mansinghpur, Bijhrauli, and Dulwar villages in the south; Amthanwa village in the east and Mahtri Dharamchand and Chakaiya villages in the west (DFAFRD, Govt. of Bihar). The population of the adjoining areas is mostly fishermen and they were solely dependent on fishing for their livelihood, but due to scarcity of water in the wetland they have shifted to agricultural practices (CNHBSI 2018).

This wetland has a vast reservoir of a large number of fish. The faunal includes Catlacatla, Labeobata, Labeocalbasu, Notopterus, Puntiusticto, Puntiussophore, Puntiuschrysopterus, Oxygasterbacaila, Wallagoattu, Mystustengra, etc.(CNHBSI 2018).This wetland has important ecosystem benefits such as controlling flood, replenishing groundwater, providing fish, fodder, and vegetables (Aslam A et al, 2022). Loss of biodiversity in and around the wetlands is caused by the over exploitation of resources by the local communities (Roy M B et al., 2015)

REVIEW OF LITERATURE

Brinkmann K. et.al, 2020, studied the spatial and temporal dynamics of urban wetlands in an Indian megacity over the past 50 years. The study tries to investigate how much transformation of wetlands has taken place in urban as well as rural areas between 1965 and 2018. For the classification of objects, they have used multi-temporal corona and Landsat images. Further, they have done LULC for change detection. They used various indices for the comparison of open water surface and vegetation like potential wetland degree, for a degree of urbanization they used the survey stratification index (SSI). The results show that there is a drastic change in rural-urban land cover pattern. Urban wetlands completely lost under various constructions while rural wetlands were converted into green spaces. To ascertain whether the changes in urban wetlands that have been seen are due to a change in the ecological regime, more research should be carried out.

Singh D K et.al, 2019, studied the chemical characteristics of surface water of the Baraila wetland of Vaishali district Bihar on 12 selected parameters. The study tries to find out the chemical variations in the surface water of Baraila Lake. The samples were collected at three distinct locations—Loma, Dih Buchauli, and Dullour—between October 2009 and September 2010, within the seasonal period. To examine the impact on aquatic life, they have taken into account chemical parameters such as PH, DO, chloride and many more.

Aslam A et.al, 2022, explained the differential responses of hydrochemical factors and LULC changes on the spatial and temporal hydrogeochemistry of the eco-sensitive Baraila wetland. Data has been collected in 3 different seasons i.e. pre-monsoon, monsoon, and post-monsoon with the help of multivariate statistics. According to the study, eutrophication and a high abundance of aquatic plants cause serious problems that degrade the wetland's aquatic environment.

Kumari P et.al, 2023, has assessed the water quality using various parameters like water temperature, PH, DO, Chemical oxygen, etc. There has been no spatial variation in the concentration of water quality during the study period. The correlation matrix shows that there is a negative correlation between the micronutrients and macronutrients. The study suggests that water quality parameters should be monitored on a seasonal basis.

Ashraf M. and Nawaz R. (2015) compared the change detection using different bands, and algebras for Baraila wetland with NASA's multi-temporal Landsat dataset. In this study they have done a comparison between four indices i.e. Normalized difference water index (NDWI), Normalized difference vegetation index (NDVI), and Normalized difference moisture index (NDMI). Data were collected from satellite images, and for increased accuracy, a multiband technique was applied along with all resolutions, including spatial, spectral temporal, and radiometric. An extensive field survey was done with the help of GPS in March 2014. The surface water level of Baraila Lake is rapidly declining, along with the aquatic life which is present there. Therefore, the local government and administrations must take the necessary actions to prevent the wetland surface water area from further decreasing and try to restore it to its original state.

Singh K, et al., (2021) carried out research on the issues and potentials for the conservation of wetlands with special emphasis on Salt Lake in Rajasthan. Satellite data of Landsat MSS, TM, ETM, OLI images from USGS, GLOVIS portal, and the Improved dark object subtraction (IDOS) method used in ERDS. Imagine Modeler 2014 Software has been used and then normalized difference water indices (NDWI) have been calculated. The study found that there has been rapid degradation of Sambhar salt lake due to the development of private salt manufacturing units (PSMUS), water diversion, industrial salt waste dumping (ISND) cutting and flattening of the hills, installation of illegal borewells, agricultural land transformation which heavily impacted the livelihood of the region and also led to the destruction of habitats of migratory water birds. So, by involving international wetland organizations many issues can be resolved.

Roy M.B et al, (2015), analysed the research trend of wetland conservation and management using the bibliometric method. This study concluded the trend of wetland community education shifting from scientific conservation of wetlands to conventional ways of conservation through applying local knowledge and technology.

Ghose D S,(2006), provided a thorough description of wetlands, their types, and India's Ramsar wetlands, North Indian wetlands, wetland's benefits, utilisation of wetlands in Bihar, wetlands challenges, and recommendations for their conservation and management. Wetlands are found in several states in northern India. However, there were Kawar Tal and Baraila Tal in Bihar. The wetlands provide several advantages, including: groundwater discharge, water supply, shoreline stabilization, erosion control, natural waste water receptacle, enhanced water quality,

serves as a buffer zone, promotes ecological growth, and develops tourism. Wetlands in Bihar preserve the subterranean water table, aquaculture, and fishing cultivation, which serves as a lifeline for the local population. In spite of all the benefits, certain problems are also evident: eutrophication, industrial runoff, population pressure, urbanization, water system regulation, unplanned agriculture, and agricultural runoff. These problems are causing some of the wetlands in Darbhanga and Madhubani to become waste land, which is a serious concern. A few recommendations have been made for all of this: national wetland policy, developing a new Ramsar site, motivating community groups to take up a local wetland, conducting workshops and seminars, raising awareness, and planning scientific research. All of these initiatives could result in improved aquatic ecosystem conservation, which would preserve the wetland's ecology and surroundings.

Prasad. S.N. et al 2002, has made an extensive review on the conservation of wetlands of India in which he focused on the states, distribution, causes and consequences of wetland loss. This provides an overview of the use of remote sensing and GIS techniques in mapping flood zones, tracking crop and irrigation patterns, analyzing and modelling water quality, analyzing change, and in mapping of wetlands and surface water bodies. IRS LISS III sensors has been used to delineate turbidity, aquatic vegetation, and geomorphological classes of wetland. Subsequently, a comprehensive field study has been done to gather data on biodiversity and socioeconomic surveys. GIS and field data, both need to be studied so that a proper wetland conservation network can be formed.

Durai A. J.M. et al. (2014) studied the development of potential wetlands areas using geospatial technologies. All wetlands of the area were identified in 1973 using data from remote sensing. Topographical sheets have also been utilized. A total of 2399 wetlands of various sizes have been identified in the study. The most common types of inland wetlands in this area are lakes, ponds, and tanks. Finding these new bodies of water close to the larger wetlands, aids in the development of the ecology there.

RESEARCH GAP

Literature review and academic work of the various researchers indicate that Lake Baraila has not been attended to in terms of geographical perspective. The area has been studied in various parameters such as limnology, geohydrology, biological diversity, species diversity, etc. but the geographic perspective of the lake and its surroundings need to be carried out to understand the spatial synthesis at the micro-regional level of all the phenomena (Natural and Human)

over space. The area requires attention to how nature has been humanized and how the human is being Naturalised.

The integration of both needs to be studied for the wider picture of this area. The changes over space and time display that the area around the wetlands is gradually turning into a concrete forest. The distribution and density of the population have been changing rapidly in the hinterland. Socio-economic factors determine how humans can change the portrait of a particular area. The physical nature of this area has been displaying an array of transformations such as variations in rainfall pattern, quantity and quality of the water and soil of the lake, flora, fauna, and habitat diversity. The environment and the ecology of the wetlands and its surrounding areas are continuously deteriorating. The dynamic nature of the landscape with respect to climate, land use, anthropological interventions, water supply, flora, fauna, and other environmental factors necessitates a holistic approach for the protection and conservation of these wetlands which needs a comprehensive study lacking in the previous studies.

OBJECTIVE

1. To delineate the present wetland status of Vaishali District.
2. In-depth analysis of biogeochemical parameters of Lake Baraila.
3. To study the social impact of the transformation of wetlands.
4. To study the wetlands and sustainable livelihood opportunities.
5. To analyze the role and impact of stakeholders on the environment of Baraila Lake.

NEED FOR THE STUDY

A significant factor contributing to the failure of conservation efforts is the paucity of reliable scientific data regarding wetlands. The lack of appropriate and meaningful facts on which decision-makers must base their decisions causes the conservation process to fail. Real research must be done to produce desired policy changes. The following areas need to be the focus of the research:

Basic wetland science: This includes studies on the biology, chemistry, ecology, hydrology, and consequences of global climate change, among other elements of wetlands. High-quality research in these areas helps administrators recognize issues and develop workable solutions. Research groups and funding bodies ought to be responsible for

making sure that research quality is never compromised. For the benefit of other researchers, the general public, and policymakers, the research findings ought to be published in books and research journals. Policies that support the preservation and sustainable management of wetlands must result from the research.

Socioeconomic aspects: The condition of the wetland ecosystem is influenced by the economic and social status of the local communities that surround the wetland. In this aspect, the research will be beneficial. To address the vulnerability of the poor locals, they must receive more resources and training for alternative forms of employment. A poor community would also burden and exploit the environment. This can be achieved by putting into practice carefully thought-out eco-development and eco-tourism programs. Social science studies would aid in comprehending the intricate connection between wetlands and society. It ought to concentrate on how society is impacted by the loss and degradation of wetlands and vice versa. The findings from this kind of study would not only aid in bettering wetland management, but they would also result in more effective policy in this area.

Policy regarding wetlands: Wetland policy research would be useful in locating and emphasising any policy gaps in the subject. By closing these loopholes, the policy would be strengthened, and the achievement of India's intelligent use of wetlands would be facilitated.

DATA SOURCES AND METHODOLOGY

Regarding the wetlands in the Vaishali district, primary and secondary data will be gathered. This will include topographic sheets, satellite imagery for four decades, rainfall data, demographic details and images, samples, and a socioeconomic survey.

To gather primary data, a stratified random sample technique will be applied. Data collection will involve structured questionnaire surveys, interviews, and schedules. The relationship between anthropogenic agents and the environment will be assessed using a pilot study. To validate the satellite data, a field survey will be carried out. The physical and chemical characteristics of water samples will be taken from Baraila Lake will be examined. For secondary sources of data, a toposheet on the scale of 1:50,000 from the Survey of India will be utilized to create a base map. Data spanning four decades will be taken from USGS, IRS, and various other agencies. The Space Application Centre, ISRO's National Wetland Atlas, provides an extensive description of the wetlands. For this research, rainfall data will be collected from the Central Water Commission and the India Meteorological Department. To

collect demographic data, the Census of India website will be utilized. The forest department and additional sources will be consulted for information on the flora and wildlife.

In terms of data analysis GIS software will be used to analyse land cover and land use using satellite images. The Normalized Difference Water Index (NDWI) and the Modified Normalized Difference Water Index (MNDWI) will be used for waterbody mapping. The Topographic Wetness Index (TWI) will be used to quantify the impact of topography on hydrological processes.

The physical and chemical characteristics of the water will be evaluated to determine its quality. The results will be computed and plotted using GIS and SPSS software. The Normalized Difference Vegetation Index (NDVI) and Vegetation Growth Index (VGI) will be used to determine the vegetation cover and growth status concerning the biological aspect. Field observations and a questionnaire survey will be used to supplement the secondary data sources used for the analysis of the flora and fauna. In this study, various methodologies such as correlation, multivariate analysis, and the Mann-Kendall Test will be employed.

With GIS software, the variables will be mapped for LULC, NDWI, MNDWI, NDVI, VGI, and other indices. Data tabulation and report writing will be done using Microsoft Office and statistical software.

STUDY AREA

Bihar's Vaishali district holds immense historical significance being the birthplace of Jainism's founder, Lord Mahavira, and the first republic in history. The Ganga, Gandak, and tributaries of Gandak bring alluvium to this territory which is rich in lime and potash entisols and inceptisols (Dwivedi S et.al, 2019). There are a few minor areas in the district that are permanently flooded. The district contains 9036 hectares of wetlands, the largest of which is the Baraila lake or wetland. Baraila Lake and Baraila Wetland will be used interchangeably in this study (Dwivedi S et.al, 2019).

The Baraila wetland is a seasonally flooded area located in the Gangetic plains of the Vaishali district of Bihar. It has an aggregate area of 12.7 Km^2 located in between 25°45’58" & 25°45’37" North latitude and between 85°31’48" & 85°34’50" East longitude (CNHBSI 2018). It has immense ecological and environmental importance in the development of wetlands and aquatic ecosystems (Kumari P et.al, 2023). However, it was listed as Baraila Lake Salim Ali Jubba Sahni Bird Sanctuary in the Indian Gazette in 2016 (Gazette of India, 2016). The wetlands dry completely in the summers (May–June), and grasses take the place of the

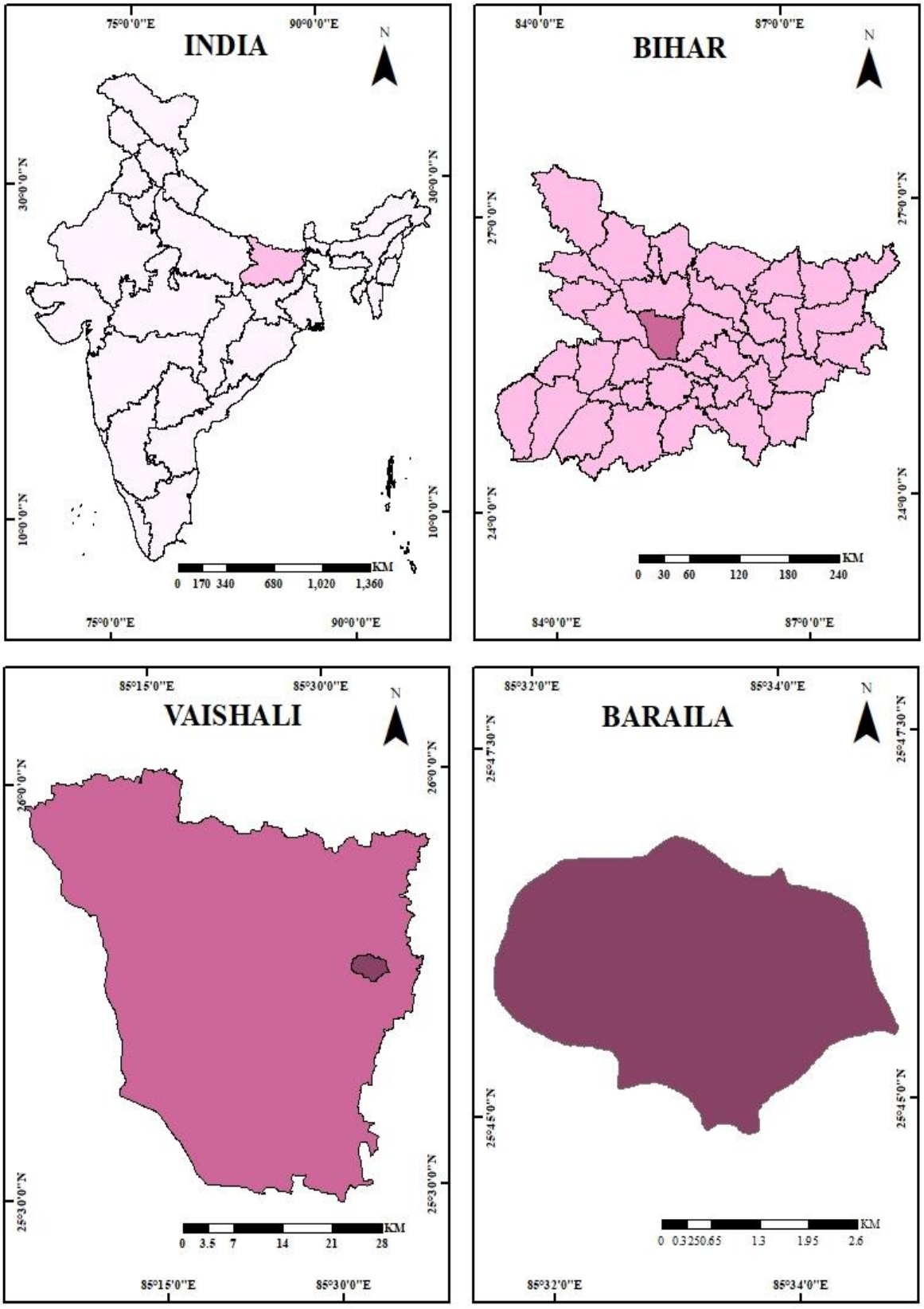
wetland's flora. The sanctuary becomes a wetland when the monsoon arrives at the end of June and draws water from the catchment region. The Gandak Canal, the Baya River, and the Noon River are other water sources in the sanctuary. Water birds that migrate depend on the wetlands of the Gangetic plains for their survival. it serves as a habitat for a variety of fauna, including fish, amphibians, and reptiles, in addition to resident and migratory water birds. The main resident species of this sanctuary include the Indian Shag, Red-collared Dove, Asian Koel, Small Bee-catcher, Brahmany starlet, and tree pie; the migratory birds include Black Ibris, Brahmany Shell Duck, Bar-headed Goose, Oriental Magpie Robin, and Lesser Whistling Duck. This wetland is surrounded by four rivers e.g. Gandak, Nuna, Burhi Gandak, and Ganga. Wetland is surrounded by eight villages along its boundary: Kawai Baraila in the north; Loma, Mansinghpur, Bijhrauli, and Dulwar villages in the south; Amthanwa village in the east and Mahtri Dharamchand and Chakaiya villages in the west.

Geographical perspective:

Baraila Wetland experiences a monsoon-type climate. Winter begins in December and lasts until February; summer arrives in March and lasts until June. Rainfall of the southwest monsoon takes place from July to September, and the retreating monsoon begins in October and lasts till November. The majority of the water during July and August comes from the southwest

monsoon. The region receives 1168 mm of rain on average per year. The summertime temperature can reach 40°C, while the wintertime temperature fluctuates between 16°C and 4°C. The range of humidity is 60% in April and May and 90% in July and August. Bihar's vegetation is mostly made up of dry deciduous trees (Champion & Seth, 1968). Nonetheless, this wetland's vegetation might be classified as a form of grassland. (CNHBSI 2018)

STUDY AREA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VAISHALI
85°15'0"E
85°30'0"E
26°0'0"N
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BARAILA
85°32'0"E
85°34'0"E
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TENTATIVE CHAPTER SCHEME

CHAPTER 1

Conceptual Framework of the Study

CHAPTER 2

Wetland scenario of Vaishali District

CHAPTER 3

Analysis of the Baraila Wetland

CHAPTER 4

Social impact of the transformation of wetlands

CHAPTER 5

Wetlands and Sustainable livelihood opportunities

CHAPTER 6

Summary and Conclusion

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